Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

CIRCULAR NO. 145 NOVEMBER, 1930
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

LIBRARY
RECEIVED
★ DEC 10 1930 ★
U. S. Department of Agriculture

TIPHIA POPILLIAVORA ROHWER, A PARASITE OF THE JAPANESE BEETLE[1]

By J. L. King, *Senior Entomologist*, and J. K. Holloway, *Assistant Entomologist, Division of Deciduous-Fruit Insects, Bureau of Entomology*[2]

CONTENTS

	Page		Page
Introduction	1	Difficulties in importation	4
Distribution and strains of *Tiphia popilliavora*	2	Early colonization and establishment	5
Life history and habits of *Tiphia popilliavora*	2	Colonization during 1927	5
Seasonal occurrence	2	Recovery from colonies of 1927	7
Food plants	3	Colonization during 1928	7
Mating habits	3	Colonization during 1929	7
Egg laying	3	Collection	8
The egg	3	Colony distribution	8
The larva	4	Recovery	9
The cocoon	4	Summary and conclusions	9

INTRODUCTION

The purpose of this circular is to give a brief account of *Tiphia popilliavora* Rohwer, a wasplike parasite, which was introduced into this country as one feature of a comprehensive plan to bring about control of the Japanese beetle (*Popillia japonica* Newman) through its natural enemies.

The Japanese beetle is a foreign insect which was accidentally introduced into this country apparently free from all its insect enemies and true parasites. It has found a congenial land with food and favorable climate, and so has multiplied without check until it has become one of the major insect pests in some of the Eastern States.

In Japan this beetle is found distributed commonly over a wide area but rarely occurring in sufficiently large numbers to cause serious injury to crops. This is mainly because in that country there are several true parasitic enemies of this beetle which are very effective in checking its rapid increase.

The logical thing to do under the foregoing circumstances would be to transfer, if possible, the insect enemies of the Japanese beetle from Japan to this country in the hope that they would eventually become as effective here as there. This method, termed "biological

[1] Contribution No. 67 from the Japanese beetle laboratory, Moorestown, N. J.

[2] The writers wish to acknowledge with appreciation the work of many contributors during the early history of this species. Special acknowledgment is due R. W. Burrell, J. W. Balock, and R. T. White, of the Japanese beetle laboratory, who assisted materially in the colonization work of 1929, and to H. C. Hallock for the work in Long Island, N. Y. The photographic work by R. L. Coffin, of this laboratory, is also gratefully acknowledged.

control," which has been successful in the case of a number of other introduced insect pests, is now being applied in the control of the Japanese beetle. The introduction of foreign parasites into this country for the control of the Japanese beetle was begun in 1920 and has been carried on continuously since that time by the United States Bureau of Entomology in cooperation with the New Jersey State Department of Agriculture. During this 10-year period (1920–1929) 14 species of parasites and 1 predacious beetle have been received and liberated. These have come from Japan, Chosen, China, and India. Of this number only 5 have become established; some of these are only recent introductions, consequently it is too early to predict their success or failure. With others, establishment has been slow, and more time will be required before their true status can be determined.

Tiphia popilliavora was one of the first parasites introduced and one which gave little promise at first. After a slow start, however, it is now increasing rapidly and gives much promise as an important factor in the biological control of the Japanese beetle.

DISTRIBUTION AND STRAINS OF TIPHIA POPILLIAVORA

Tiphia popilliavora is a hymenopterous parasite of the larval stage of the Japanese beetle. (Pl. 1, B.) The adult female is about 10 millimeters long, and the male is slightly smaller. This species was first found at Koiwai, Japan, during August, 1920.[3] Investigations have revealed that although this species is abundant locally in Japan, it has a wide distribution, occurring also in Chosen and China on other species of Popillia. In the systematic classification the strains from Chosen and China are regarded as the same species as the Japanese form, for they are apparently identical morphologically. This identity is further borne out by a general similarity of habits. However, they differ in seasonal appearance and in the fact that they are parasites of species of Popillia other than *P. japonica*. This seasonal difference is sufficiently great to make it best, for practical purposes in biological control, to consider the Chosen and Chinese strains separately. This circular deals only with the Japanese form.

LIFE HISTORY AND HABITS OF TIPHIA POPILLIAVORA[4]

SEASONAL OCCURRENCE

This Tiphia has but one generation per year. The adults occur in the field during August and early September, when both males and females may be found frequenting the flowers of wild carrot. The first to appear are males, which emerge about the latter part of the first week in August (August 7, 1928, and August 5, 1929). Females do not occur in numbers until three or four days later. Collections made during 1929 indicate that the maximum numbers of females are on the wing between August 19 and 26.

---

[3] CLAUSEN, C. P., KING, J. L., and TERANISHI, C. THE PARASITES OF POPILLIA JAPONICA IN JAPAN AND CHOSEN (KOREA) AND THEIR INTRODUCTION INTO THE UNITED STATES. U. S. Dept. Agr. Bul. 1429, p. 33–41, illus. 1927.

[4] A detailed account of this species is found in Department Bulletin 1429 (see footnote 3); however, it should be noted that some changes have been made here which are in accord with the species as now established in the eastern part of the United States.

FOOD PLANTS

In Japan, *T. popilliavora* was found most frequently on the flowers of two umbelliferous plants and one Polygonum.[5] Here in its new environment it is found almost exclusively on the flowers of wild carrot (*Daucus carota* L.), which is coincidentally an umbelliferous plant of foreign origin. (Pl. 1, A.) The occurrence of *Tiphia popilliavora* on other plants seems to be mostly incidental, as these insects have not been observed to feed even where aphids have covered the leaves with honeydew. Various sweetened sprays have been tried out as attractants to facilitate collecting, but these have failed for the most part in enticing the adults to foliage.

MATING HABITS

The females mate almost immediately after their initial emergence from the soil in which their cocoons were formed. In areas inhabited by this parasite, numerous males may often be seen swiftly flying a few inches above the soil or grass in a weaving flight in search of emerging females. Mating generally occurs on low vegetation; frequently, however, mating pairs are seen on carrot blossoms.

EGG LAYING

The female parasite probably locates the host[6] grubs in the soil through the sense of smell. She burrows into the soil and, upon locating the beetle grub, enters the soil cavity in which the grub lives and feeds. She then climbs on the anterior portion of the back of the host, clinging firmly to prevent displacement as the grub writhes in resistance. The sting-bearing tip of the abdomen is then curled to the under side of the grub between the legs, and the sting is inserted several times, causing an immediate but temporary paralysis and relaxation of the host, which lasts until after the egg laying is completed. The Tiphia then kneads the ventral surface of the abdomen of the paralyzed grub with her mandibles, particularly the area about the fifth and sixth segments. This accomplished, she curls herself in a loop about the host and with the tip of her abdomen by a rhythmic motion cleanly polishes the ventral surface of the grub in the furrow between the fifth and sixth abdominal segments. After several minutes of this cleaning, she deposits the egg in the furrow. The egg is held in place by a mucilaginous cement excreted when the egg is deposited. The entire process of egg laying requires from 20 to 30 minutes.

Often after the egg-laying activities the Tiphia feeds by nipping a small aperture in one of the forelegs of the grub and drinking the droplet of fluid which exudes from the wound.

THE EGG

The egg is placed within the segmental crevice of the fifth and sixth abdominal segments with the anterior pole, or head end, of the egg directed toward the median ventral line of the host. (Pl. 2,

[5] See footnote 3.
[6] Host is the term commonly applied to the insect which is attacked by the parasite.

A.) The egg is about 0.5 millimeter long, and is a clear translucent white. The egg stage lasts from five to seven days, depending on the temperature. Females of this species may deposit 30 to 45 eggs during their life period, which may be 22 days or a little longer.

THE LARVA

Soon after the egg laying has been completed the host grub recovers from the temporary stupor caused by the sting and apparently resumes a normal activity. The egg hatches in from five to seven days, and the young parasite starts to feed by sucking the body fluids of the host. The parasite larva (pl. 2, B) remains fixed and continues to suck the body fluids until its fifth or last larval stage. By this time the host has become weakened and soon dies, and from then on the parasite (pl. 2, C) gives up the suctorial method of feeding and devours the host by the use of its mandibles, leaving only the tough head capsule and portions of the legs. This period is marked by extremely rapid growth. The period of larval growth to the spinning of the cocoon ranges from 18 to 30 days. There are five larval molts during this period.

THE COCOON

When the host is entirely eaten, the parasite larva immediately begins to spin a silken cocoon within the soil cell formerly occupied by the host. (Pl. 3.) The cell is completely filled with a loose floss, and the finished cocoon rests suspended in this, quite free from the soil walls of the cell. (Pl. 3, A.)

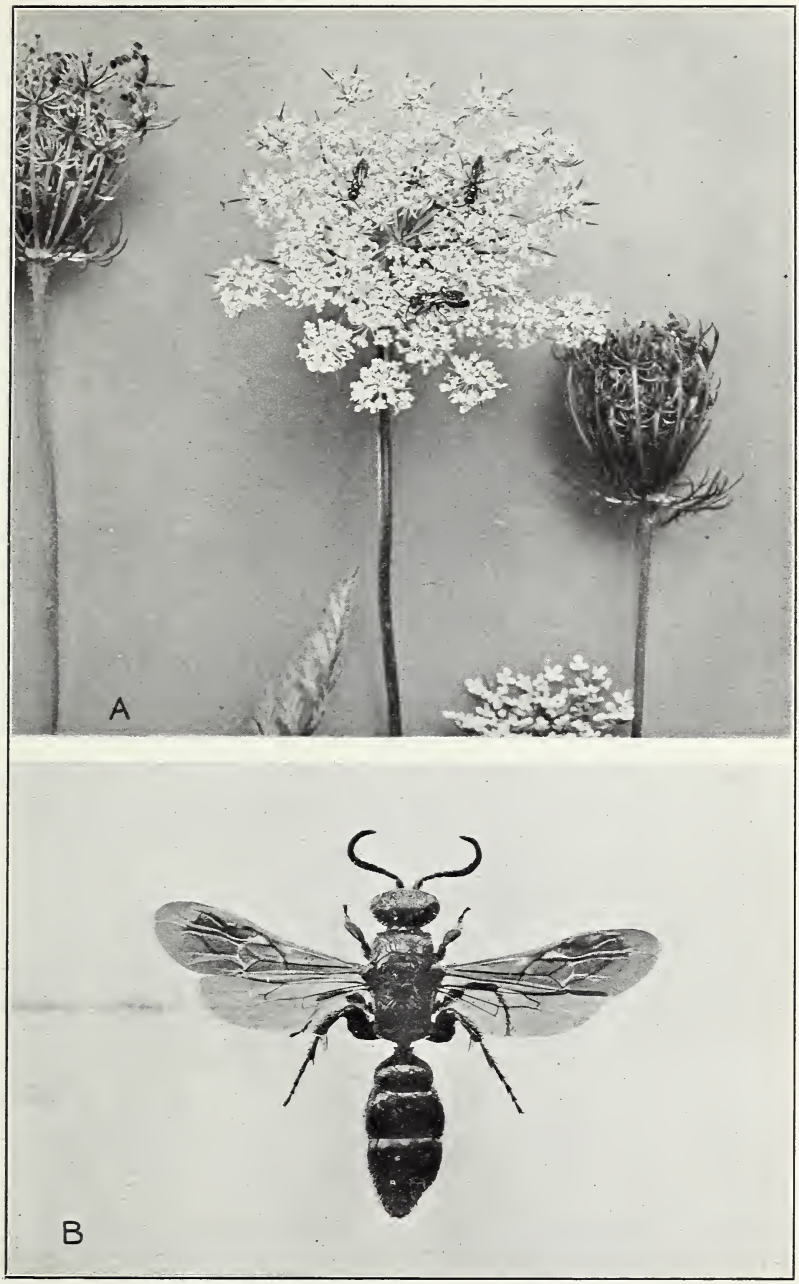
The larva remains dormant within the cocoon throughout the fall, winter, spring, and early summer. Pupation takes place only a short time before the adults appear in August.

DIFFICULTIES IN IMPORTATION

Considerable difficulty has been experienced in the introduction of this Tiphia. In Japan the host material on which it was reared was at times difficult to obtain, and collections of Japanese beetle grubs generally suffered a 50 per cent mortality. The number of cocoons reared and shipped from Japan was 395 in 1920, 905 in 1921, and 2,050 in 1922, a total of 3,350 cocoons. These cocoons were obtained from approximately 10,000 ovipositions.

At the receiving station further difficulties were encountered, as this species under rearing conditions in the insectary is most susceptible to fungous diseases. Losses of reared adults often resulted from their low vitality, and frequently the males emerged so much earlier than the females that their numbers were depleted by the time the females emerged.

In August, 1925, an experimental shipment of field-collected adults was sent from Japan; of the 1,030 females shipped only 43 were received alive, and many of these were weakened by their long confinement in transit. A second shipment of adults was attempted in August, 1926, and of this material only 22 survived. These females were used in an experiment in artificial propagation, but none of their progeny reached the adult stage.



ADULTS OF TIPHIA POPILLIAVORA AND HOST PLANTS

A, *T. popilliavora* feeding on flowers of wild carrot. Three-fourths natural size; B, female *T. popilliavora*. Enlarged four diameters.

EGG AND LARVAL STAGES OF TIPHIA POPILLIAVORA

A, Japanese-beetle grub bearing the egg of parasite *T. popilliavora*. The arrow points to the egg. Enlarged three diameters; B, Japanese-beetle grub with young parasite larva attached and feeding. Enlarged three diameters; C, parasite larva almost fully grown feeding on remains of beetle grub. Enlarged four diameters.

EARLY COLONIZATION AND ESTABLISHMENT

The first liberation of this species consisted of a few individuals which survived the vicissitudes described. They have since proved to have been sturdy survivors and have repaid the effort and expense involved in their introduction. The first three successful colonies originated from liberations made by L. B. Smith, T. H. Frison, and H. A. Jaynes, who were conducting the domestic work at that time. Liberations were made as follows:

No. 1. The first colonizations were made in 1921 and 1922 at Cinnaminson, N. J. A few adults of both sexes were released; the exact number is not recorded, but it did not exceed 50. In 1926 a colony was found to have become established; at that time numerous males were observed on the flowers of wild carrot, and parasitized Popillia grubs were found in the same locality. Scouting indicated that the colony covered an area of approximately 4 acres. During August, 1927, adults of both sexes occurred in surprising numbers, and the colony had spread to an area of 1 square mile.

No. 2. The second attempt at colonization was made near Cinnaminson at a place called Siebke's pasture. The first releasement, in August, 1921, consisted of two mated females that had already deposited some eggs in captivity; and the second releasement, in August, 1923, consisted of six females. Recovery of two males was made at this locality in August, 1927.

No. 3. The third colonization was at Lippincott's pond, between Moorestown and Cinnaminson. There 45 mated females were released in 1922 and 9 more the following year. By August, 1927, the colony had spread over an area of approximately one-half square mile.

No. 4. The fourth place of liberation is known as Lippincott's pasture, near Moorestown. The releasement consisted of the 43 survivors of the initial shipment of adults received in September, 1925. To date (1929) no recovery has been made.

In 1928 the three established colonies were scouted and enough recoveries were made on their outer limits to indicate a union. In 1929 this union was clearly evident, as males and females were found in abundance in the intervening areas, thus bringing the three colonies together, in an area of approximately 3½ square miles. (Fig. 1.)

COLONIZATION DURING 1927

As the colony in the Cinnaminson area had increased so astonishingly in numbers, it was concluded that by collecting and artificially disseminating the females a greater and more rapid dispersion could be obtained which would at the same time reduce competition within the colony center and facilitate the maximum increase of the parasite. In view of the success of the original releasements, it was believed that units of 100 females for each colony should give positive results. It has been observed in the field that female Tiphia mate almost immediately on initial emergence from the soil in which their cocoons are located. Thus practically all females collected from carrot and used in artificial dispersion have mated.

Collections were made in the field during August, 1927, and 1,125 females were taken, 900 of these being released in lots of 100 each, in nine localities in Pennsylvania and New Jersey. One lot of 125 was shipped to Westbury (Long Island), N. Y., for releasement in an area infested with the Asiatic beetle, *Anomala orientalis* Waterh.[7] The remaining 100 were held in the insectary for oviposi-

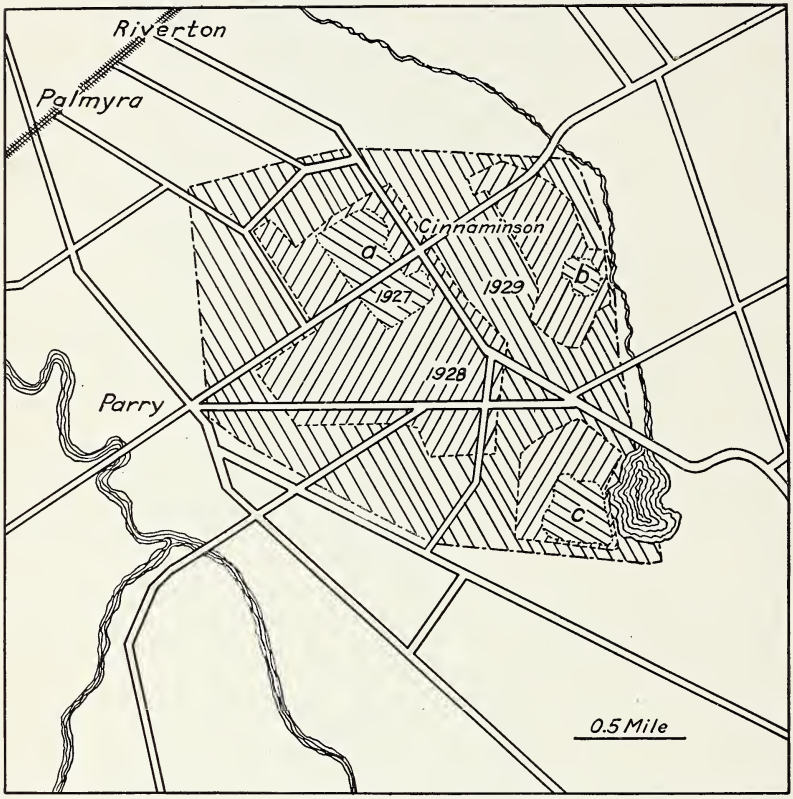


FIGURE 1.—Map of the three original colonies of *Tiphia popilliavora*, showing their growth from 1927 to 1929, inclusive: *a*, Center of Cinnaminson, liberations of 1921 and 1922; *b*, center of Siebke's pasture, liberations of 1921 and 1923; *c*, Lippincott's pond, liberations of 1922 and 1923

tion on Popillia grubs. From this lot 2,957 eggs were obtained. These, on their host grubs, were placed in the field, thus forming the nucleus of another colony, bringing the total number of colonies to 11 for 1927. These colonies are listed in Table 1.

[7] During the summer of 1926 a series of tests were made to determine whether *T. popilliavora* would accept the Asiatic beetle as a host. The results obtained in the insectary were highly favorable, and in 1927 the above shipment was made to the Westbury vicinity as a practical test; here 110 females were liberated and 266 parasitized Anomala grubs were "planted" out. No recoveries have so far been made from this releasement.

TABLE 1.—*Colonies of Tiphia popilliavora started in 1927 and recoveries from them in 1928*

Locality	Tiphia placed in field in 1927	Number of Tiphia females released	Recovery in 1928	Condition of habitat
Ellisburg, N. J	Aug. 19	100	August	Satisfactory.
Vincentown, N. J	Aug. 20	100	do	Do.
Parkville, N. J	Aug. 22	100	do	Do.
Berlin, N. J	Aug. 23	100	None	Doubtful.
Columbus, N. J	Aug. 24	100	August	Satisfactory.
Indian Mills, N. J	Aug. 27–31	100	None	Doubtful.
Birmingham, N. J	August and September.	(1)	August	Satisfactory.
Collegeville, Pa	Aug. 19	100	do	Do.
Emilie, Pa	Aug. 25	100	do	Do.
Bustleton, Pa	Aug. 30	100	do	Do.
Westbury, N. Y	Aug. 22–26	125	None	Doubtful.

[1] This releasement consisted of 2,957 parasitized Japanese beetle grubs.

RECOVERY FROM COLONIES OF 1927

During August, 1928, the 11 releasements of 1927 were scouted for adults, resulting in recoveries in eight places, including the locality where parasitized grubs had been placed in the field. Three localities, namely, Indian Mills and Berlin, N. J., which were questionable at the start, and Westbury, N. Y., gave no recoveries. These failures may have been due to the fact that the localities in New Jersey were only sparsely infested with Popillia at the time the releasements were made, and the releasement at Westbury may have failed because of the change of host. On the other hand, recovery from any of these localities in the future is quite possible.

These recoveries clearly indicated that where units of 100 field-collected female Tiphia were liberated under favorable conditions establishment was almost certain. It was found that a satisfactory colonization point may be one in which Popillia breeding ground, moderately drained, is plentiful, and in which host larvae occur at the rate of at least one per square foot. Also, wild carrot (*Daucus carota*), the favorite food plant of *T. popilliavora*, must be present in fair abundance.

COLONIZATION DURING 1928

During August, 1928, a second collection of Tiphia was made at Cinnaminson, and 4,330 females were procured for further colonization. This material was released in lots of 100 or more females in 30 localities within the heavily Popillia-infested areas of Pennsylvania and New Jersey. On Long Island a releasement of 200 adults was made at Flushing, which is in an outlying infestation of Popillia.

In the areas infested with *Anomala orientalis* two liberations were made, one at Jericho, N. Y., of 200 Tiphia females and 118 parasitized Anomala larvae, and another at New Haven, Conn., of 290 Tiphia females.

COLONIZATION DURING 1929

In the Cinnaminson area in 1929 the first emergence of *T. popilliavora* was noted August 5, at which time males were abundant.

Only three females were seen on the first day of emergence. An attempt to collect the adult parasites in numbers was made on August 9, at which time six collectors were able to obtain only 100 females. After a delay of three days a second attempt was made, resulting in 200 females, and from this time on collecting was continuous, except Sundays, until August 28.

As it was desirable to place as many colonies in the field as possible, five extra men were employed. The work was divided into two parts, collection and colonization.

COLLECTION

During the first nine days of the month the extra men prepared equipment, such as collecting tubes with plaster of Paris bottoms and receiving tins for transportation to new fields. (Pl. 4.) A temporary field cage, in which to transfer material from tubes and containers, was constructed in the center of the collecting area. (Pl. 4, D.) As soon as the Tiphia began to appear the collectors were taught to recognize them. Then a hasty survey was started to determine the extent of the area. The collectors were required to bring in all Tiphia, males and females, for further verification, and from data so obtained the extent of the colony was estimated.

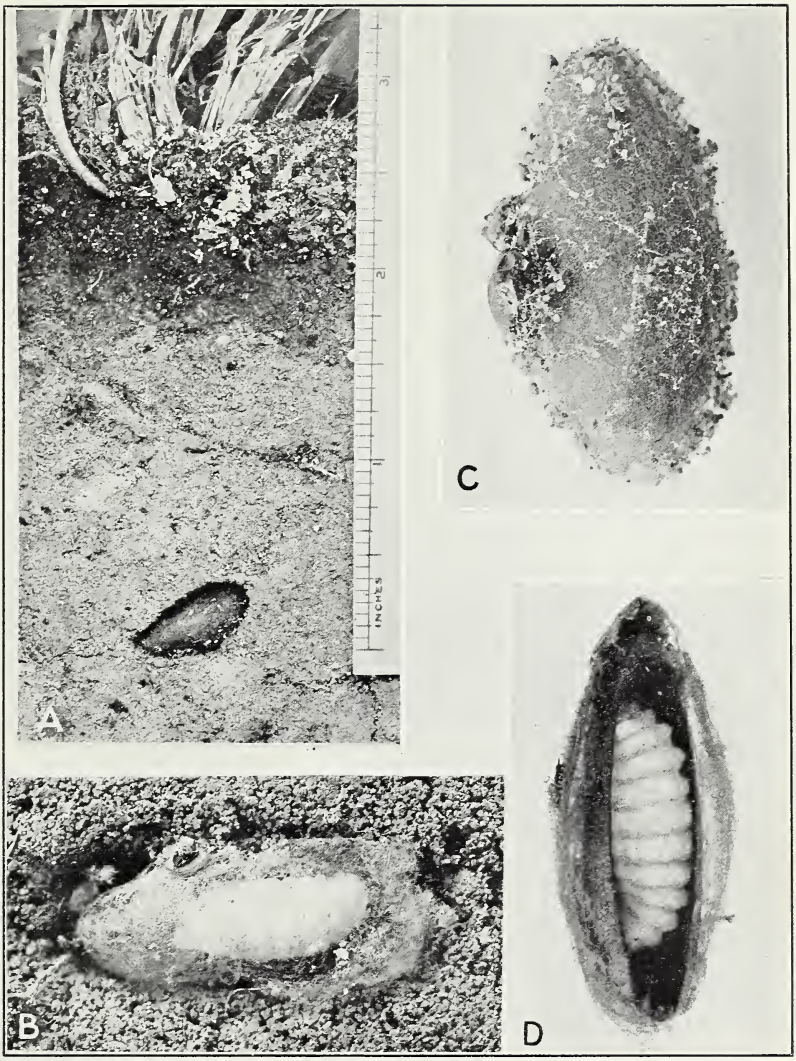
Within the area determined for 1929 (fig. 1) there was a very noticeable increase in numbers over the previous year, and it was found that profitable collecting could be conducted almost anywhere within the area.

The number of men collecting varied from day to day, but the average was seven over a period of 17 days. During this time the daily average collection was 594 females, an average of 84.9 per man. The total collection amounted to 10,100 females.

COLONY DISTRIBUTION

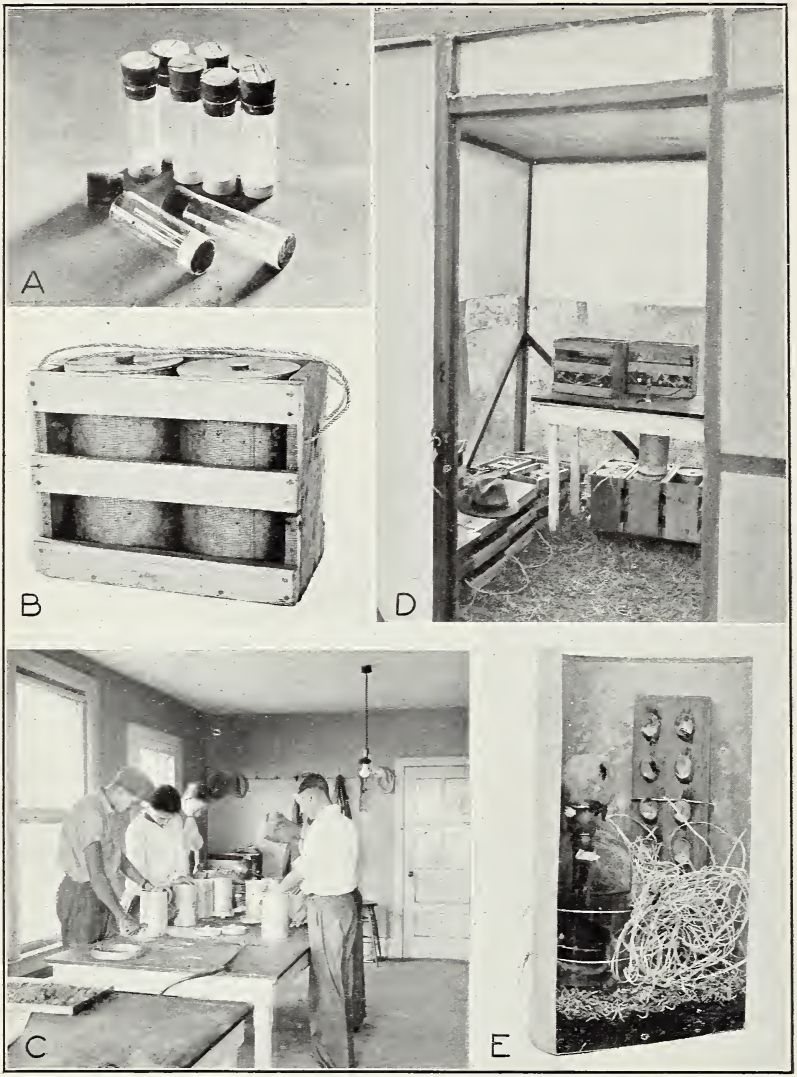
R. W. Burrell, junior entomologist, with the assistance of two men, took charge of the placing of colonies. The area for colonization was divided into four districts, three in Pennsylvania and one in New Jersey. Each day's collection of Tiphia was distributed the following day in one of these sectors. Extreme care was used in selecting the exact points of liberation, especially to see that beetle larvae were present over extensive grasslands and that wild carrot was in close proximity to these areas. The 10,100 Tiphia were thus distributed in 100 local colonies of 100 each, only one outlying colony of 100 being placed in Harrisburg, Pa. The exact location of each colony was carefully noted on topographic maps.

The colonies which were started during 1928 and 1929 are listed in Table 2.



THE COCOON OF TIPHIA POPILLIAVORA

A, Tiphia cocoon located in the soil within the cell formerly occupied by the host grub. About natural size; B, Tiphia larva spinning cocoon. Note the remains of the head of a beetle grub. Enlarged four diameters; C, completed cocoon with the remains of head of the beetle grub attached to the loose threads of the cocoon (at left). Enlarged four diameters; D, Tiphia cocoon cut open showing the larva in hibernating condition. Enlarged four diameters.



EQUIPMENT USED IN THE COLLECTION AND DISTRIBUTION OF TIPHIA POPILLIAVORA

A, Vials used in collecting the female Tiphia from carrot blossoms. The plaster of Paris bottoms keep the vials from "sweating" and also keep the inclosed air moist; B, tins in a crate ready to be taken to the field. Each tin contains 100 to 150 female Tiphia; C, preparing tins and other apparatus used in collecting and distributing Tiphia over the beetle-infested area; D, field cage with necessary collecting apparatus. This was set up near the collecting center where Tiphia females were collected for further distribution; E, cross section of a receiving tin used for transporting Tiphia to new fields. Note the water bottle with wick feed, the stick with candy for food, and soil at bottom of tin which is held in place by wire mesh over moss.

TABLE 2.—*Colonies of Tiphia popilliavora started in 1928 and 1929*

State and county	Township or town	Colonies of 1928	Colonies of 1929
New Jersey:		*Number*	*Number*
Burlington	Beverly		4
Do	Bordentown		3
Do	Burlington	1	
Do	Chester	2	
Do	Delran		1
Do	Easthampton	1	
Do	Florence	1	2
Do	Lumberton	1	
Do	Mansfield		5
Do	Medford	1	
Do	Northampton	1	
Do	Springfield	2	
Do	Westhampton	2	4
Do	Willingboro		5
Camden	Pensauken	2	
Do	Delaware		1
Gloucester	Deptford		2
Do	Mantua		4
Do	Monroe		2
Do	Washington		1
Do	Glassboro		1
Do	Harrison		4
Mercer	Trenton	1	
Do	Ewing		1
Pennsylvania:			
Bucks	Bensalem	2	8
Do	Bristol	2	3
Do	Middletown		7
Do	Newtown		1
Do	Northampton		1
Do	Southampton		2
Pennsylvania—Continued.		*Number*	*Number*
Delaware	Haverford	1	6
Do	Radnor		1
Do	Ridley	1	2
Do	Springfield		2
Do	Upper Darby	2	
Montgomery	Abington	3	3
Do	Cheltenham	2	2
Do	Lower Merion		11
Do	Moreland		2
Do	Springfield	1	
Do	Upper Merion		1
Do	Upper Dublin	1	
Philadelphia	Philadelphia		8
Total in heavily infested area		30	100
Pennsylvania:			
Dauphin	Harrisburg		1
New York:			
Queens	Flushing	1	
Nassau	Jericho	1	
Connecticut:			
New Haven	New Haven	1	
Total in outlying districts		3	1
Grand total		33	101

Figure 2 shows the location of the colonies which were started in 1921, 1922, and 1923 in the severely infested districts of New Jersey and Pennsylvania.

RECOVERY

No recovery campaign was planned for 1929 because it appeared that rapid colonization was more important, this being justified by the abundance of material present and the success of the colonies of 1927. However, while releasements were being conducted, three of the colonies of 1928 were scouted, and recoveries were made.

SUMMARY AND CONCLUSIONS

Tiphia popilliavora Rohwer was discovered in Japan in 1920 and successfully introduced in three localities in New Jersey during 1921–1923, inclusive. The original colonies have spread and in 1929 they were united over an area of 3.5 square miles in New Jersey. Artificial distribution from this center has been conducted since 1927 and up to 1929 releasements of 145 colonies had been made. The results of the check of 1928 show that where 100 female Tiphia are liberated under favorable conditions, establishment is almost certain.

As concerns the nature and requirements of *T. popilliavora*, it may be said to be particularly well adapted for use in biological control for the following reasons: It is a specific parasite of *Popillia japonica* in its native land, and in this country this specific tendency is

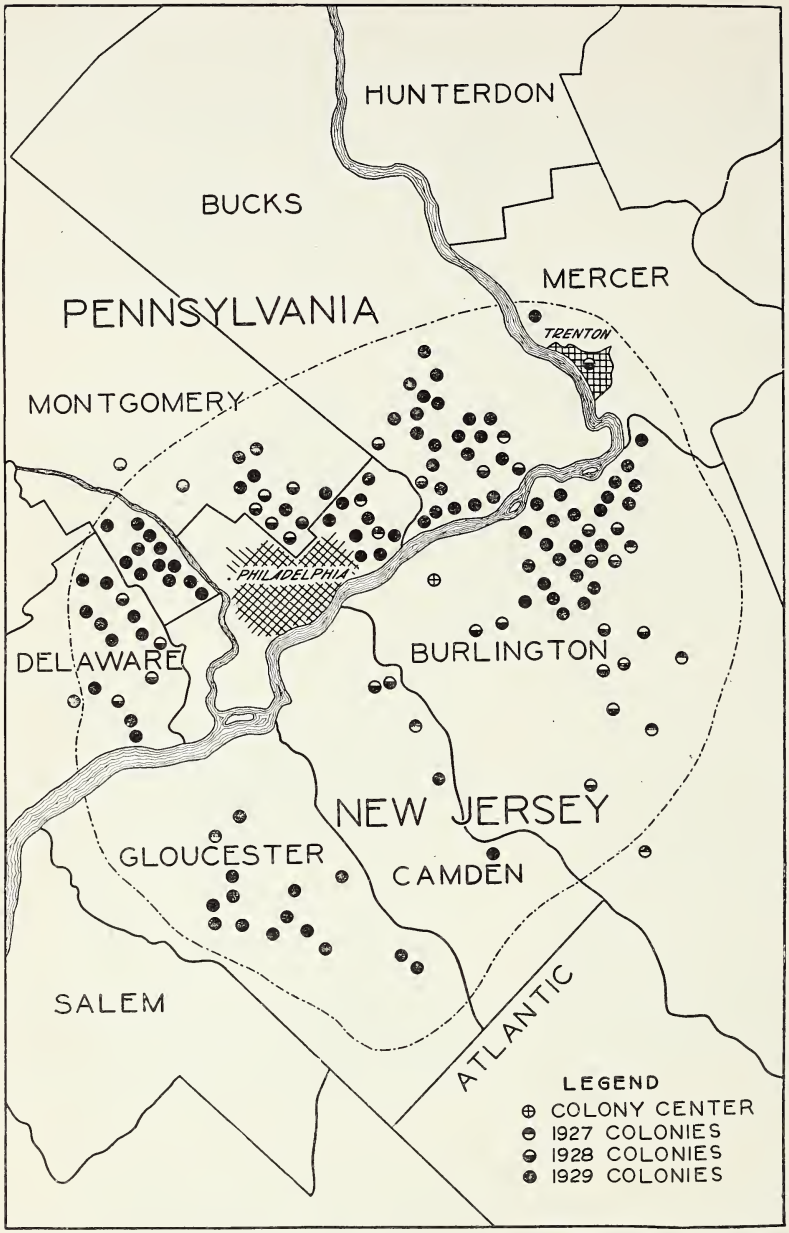


FIGURE 2.—Map showing location of colony center and distribution of colonies of *Tiphia popilliavora* started during 1927, 1928, and 1929. The broken line incloses the area of heavy infestation by the Japanese beetle

preserved.[8] Comparisons show that the time of emergence and the period of adult activity and larval development are the same here as in Japan. This indicates that the soil temperatures throughout the year are favorable for its normal development. This Tiphia frequents the flowers of wild carrot (*Daucus carota*) almost to the exclusion of other plants. In the present area infested with Popillia, wild carrot is very abundant and widely distributed. Since this Tiphia is specific in its habits and is so perfectly adjusted to its new environment and has selected an abundant food plant, it is believed that it will prove to be one of the most important parasites acting in the biological control of the Japanese beetle.

[8] This Tiphia has accepted *Anomala orientalis* as a host only under artificial conditions. If finally established within an area inhabited by both imported beetles, preference would doubtless be shown for the true host.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	ARTHUR M. HYDE.
Assistant Secretary	R. W. DUNLAP.
Director of Scientific Work	A. F. WOODS.
Director of Regulatory Work	WALTER G. CAMPBELL.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel and Business Administration.	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Solicitor	E. L. MARSHALL.
Weather Bureau	CHARLES F. MARVIN, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Plant Industry	WILLIAM A. TAYLOR, *Chief.*
Forest Service	R. Y. STUART, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Bureau of Entomology	C. L. MARLATT, *Chief.*
Bureau of Biological Survey	PAUL G. REDINGTON, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Plant Quarantine and Control Administration	LEE A. STRONG, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Director of Regulatory Work, in Charge.*
Office of Experiment Stations	———, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*

This circular is a contribution from

Bureau of Entomology	C. L. MARLATT, *Chief.*
Division of Deciduous-Fruit Insects	A. L. QUAINTANCE, *Associate Chief of Bureau, in Charge.*

U. S. GOVERNMENT PRINTING OFFICE: 1930

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 10 cents